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Size and Moisture Content of Pulp Chips From Living and Dead Engelmann Spruce and Subalpine Fir

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Sieve analysis indicates that the average size of pulp chips produced by an inwoods chipping system from live and dead timber were nearly the same — 0.53 vs. 0.49 inch. The percentage of fines passing the 3/16 inch-diameter screen was 1.7% higher for the dead than for the living timber. The average moisture content of the chips decreased from 82% for living Engelmann spruce and 107% for living subalpine fir to an average of 42% based on ovendry weight for the dead wood of both species.

Keywords: Pulpchips, residue utilization, *Picea engelmannii, Abies lasiocarpa*.

It usually takes many years for a dead tree to decompose entirely and return to the soil. In the early stages there is a high proportion of wood that is as usable as if the tree had been freshly harvested. As time goes on, however, this proportion decreases until the tree has no practical product value. Since the dead timber in a given stand often covers this entire range of deterioration, a practical question for pulp producers is: How much of this dead material can be successfully used in pulp? If pulp can be satisfactorily made from sound dead wood, a sizable fraction of the forest resource now wasted can be utilized.

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For pulping purposes, three characteristics of dead wood are of major importance — moisture content, amount of decay, and mechanical properties. Mechanical properties are in part affected by moisture content and decay. The size of chips produced is also important in pulping and can be affected by the three characteristics. The purpose of this research was to determine how chips produced from dead wood compare with those produced from freshly cut timber.

This Note describes and compares the size and moisture content of pulp chips from living and dead Engelmann spruce (*Picea engelmannii*) and subalpine fir (*Abies lasiocarpa*). The results were obtained as part of a larger study to evaluate an inwoods debarker-chipper system conducted cooperatively between Southwest Forest Industries, Inc. and the USDA Forest Service on the Dolores Ranger District of the San Juan National Forest during the fall of 1973 (fig. 1) (Sampson et al. 1974).

Figure 1.—Inwoods debarker-chipper system at field test site, Dolores Ranger District, San Juan National Forest.

The need to measure chip size and moisture content resulted from a decision to include a high proportion of dead wood in the material to be chipped in the Colorado phase of the study. Spruce-fir stands in this area contain large volumes of dead and down timber. Inwoods chipping presented a possible opportunity for harvesting such material economically.

Chips produced from the mixture of live and dead timber at this site were subsequently pulped by a sulfate process at the Snowflake, Arizona pulp and paper mill. Dead timber, including both standing and down trees, with an estimated 50% or more sound wood were brought in and chipped with the live thinnings. Some decay in these trees had reached the advanced stage where the wood was soft and crumbly. Bark retained on the dead logs after skidding and before debarking was variable, ranging from 0% to nearly 100%. The volume of dead wood chips salvaged was 62% of the total.

Pulp mill personnel judged that the pulp quality and yield from this particular mixture of chips were satisfactory when the mixture was blended with the regular supply of chips. However, since other timber sale areas would likely have a different mix of live and dead timber, this study was designed to evaluate the effects of tree species, living or dead condition, and tree size on chip size and moisture content.

The importance of chip size and moisture content in pulping has been documented (Chelsey and Robertson 1944, de Montmorency 1969, Hatton and Keays 1971, and Nolan 1959). It is generally recognized that a higher proportion of finer particles may be produced from both dry and decayed timber. Decay was not measured independently in this study; however, the effects of decay alone on pulp yield and quality is discussed by Hale (1969).

Sampling

Chips from 235 individual logs, representing a total of 31 different 10-unit van loads, were sampled. An initial sample log was selected at random from logs 1 through 9 for each van load and, thereafter, every 16th log was sampled. As each sample log was fed to the debarker-chipper, it was visually characterized as living or dead and identified as spruce or fir. To avoid production delays, chips were sampled with a wire screen "butterfly" net passed through the stream of chips from each sample log as they were blown from the spout of the debarker-chipper into the chip van. The net was of conical shape with a 12-inch-diameter opening and a depth of 20 inches; the screen mesh had square openings of approximately 0.15 inch. Each chip sample was divided between two polyethylene bags, labeled, and weighed. Chips for the moisture content analysis were placed in one bag and those for the sieve analysis in the other.

Analysis Methods

Chip Size

The 235 individual netted samples collected in the field were combined into 24 larger samples, which provided 3 replications for each of the fol-following 8 combinations of variables:

Species	Condition	Log Diameter *Inches*
Engelmann spruce	living	≥ 11
		< 11
	dead	≥ 11
		< 11
Subalpine fir	living	≥ 11
		< 11
	dead	≥ 11
		< 11

Combining samples was necessary to: (1) provide adequate sample size for a sieve analysis, and (2) be certain that each sample reflected chipper knife conditions over the duration of at least one period between sharpenings. (The effect of properly ground knives on chipper performance has been reported by Lamarche 1969.) The air-dry weights of the 24 samples ranged from 260 to 985 grams. In the sieve analysis, each sample was shaken for 3 minutes in a Williams classifier, using a set of five sieves with round openings of 1-1/8, 7/8, 5/8, 3/8, and 3/16 inches. Fine particles passing through the 3/16-inch sieve were caught in a pan. Each fraction was weighted in tared containers to the nearest 0.1 gram. The sieving procedure was exactly the same as that used regularly by the pulpmill, thus enabling direct comparison of experimental data with production data.

The percent of chips retained on each sieve and in the pan, and the average sieve size of the chips were calculated. Average sieve size of chips was calculated as follows:

$$\overline{X} = \frac{\Sigma W_i x_i}{100}$$

where:

$\overline{X}$ = average sieve size of chips or particles — inches

W_i = weight of chips or particles collected on the ith sieve as a percent of total sample weight

X_i = size of opening in ith sieve — inches

Moisture Content

The 235 moisture samples were ovendried at 103°C for 24 hours in a forced-air oven. Several of the samples were weighed after both 18 and 24 hours to be certain that the 24-hour period was adequate. Moisture content was calculated on an oven-dry basis.

Results

Sieve Analysis

The proportions of chips retained on the various sieves and the average sieve size of the chips for each combination of variables are shown in table 1. Analysis of variance of the data in a 2 by 2 by 2 factorial experiment indicated the following effects.

Table 1.—Percent of chips retained by each sieve and mean sieve size of chips for each combination of species and living or dead condition[1]

Sieve opening diameter-(inches)	Engelmann spruce		Subalpine fir	
	Living	Dead	Living	Dead
	Percent			
1-1/8	6.6	7.4	6.0	8.2
7/8	12.0	7.6	9.0	8.8
5/8	32.8	23.0	28.0	21.8
3/8	37.9	40.3	42.4	41.4
3/16	9.9	18.5	13.4	17.5
Pan	0.8	3.2	1.2	2.3
Mean sieve size of chips-inches	0.55	0.48	0.51	0.49

[1] *The percent values are the means for six observations.*

Average sieve size of chips did not vary significantly with either species or log diameter alone. Average sieve size for all Engelmann spruce was 0.51 inch and subalpine fir, 0.50 inch. The average chip size for logs with a diameter ≥ 11 inches was 0.50 inch and for logs with a diameter < 11 inches was 0.51 inch.

Chips from living trees were slightly larger than those from dead trees — 0.53 inch versus 0.49 inch. Table 1 shows that the proportion of fines retained in the pan was also lower for living timber than for dead. However, this slight reduction in chip size of 0.04 inch and increase in fines of 1.7% would not render such furnish at all unsuitable for the sulfate pulping process. The slightly smaller size of chips from dead trees probably resulted from the greater brittleness of dry wood.

Moisture Content

Analysis of variance of the moisture content data in a 2 by 2 by 2 factorial experiment indicated the following (table 2): Average chip moisture content did not vary significantly with either species or log diameter alone. The average moisture content (weight of moisture expressed as a percent of the ovendry weight of the wood) for all Engelmann spruce chips was 61% and for subalpine fir, 77%. The average moisture content for logs with diameter ≥ 11 inches was 69% and for logs with diameter < 11 inches was 68%. Chips from living trees, as would be expected, had a significantly higher moisture content than those from the dead trees. The greater difference in moisture content between the two species in the living condition as compared to dead is probably related to the physiology of the living trees. When dead trees of different species lose moisture, they tend to equalize over time, as is the case with wood products in use.

Table 2.—Moisture content[1] of pulpchips for combinations of species, living or dead condition, and log diameter

Log diameter (inches)	Engelmann spruce		Subalpine fir	
	living	dead	living	dead
	.... Percent.............			
≥ 11	76	39	110	51
< 11	88	39	105	41
Aver.	82	39	107	46

[1] *Expressed as a percent of ovendry weight of chips.*

The effect of the interaction between log diameter and species on moisture content was also statistically significant but of little practical importance. Average moisture content increased with diameter from 58% to 64% for Engelmann spruce but decreased from 81% to 73% for subalpine fir.

Conclusions

A major conclusion is that the size of pulp chips produced from various proportions of living and dead Engelmann spruce and subalpine fir would not vary enough to be of practical importance for pulping. In the range from all live to all dead wood, average sieve size decreased 0.04 inch and the percentage of fines increased 1.7%. The practice at the Snowflake mill is to carefully examine the percentage of oversize chips (> 1-1/8 inches) and fines (< 3/16 inch). An increase in fines will lower pulp yield, while an increase in oversized chips, depending on geometry, can influence the percent of screenable rejects and the pulp yield and quality. The geometry of the oversize chips must be considered; otherwise long ribbons of perfectly good chips could be rejected as oversized (Hatton and Keays 1971).

A second major conclusion is that the moisture content of chips, depending upon the various proportions of living and dead Engelmann spruce and subalpine fir, could affect pulping, chipping, and hauling costs. The average moisture content of the chips decreased from an average of 82% for living Engelmann spruce and 107% for living subalpine fir to 42% for dead wood of both species. However, the moisture content of the chips, particularly from dead timber, could be expected to vary with local and seasonal weather.

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